



**U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION**

PERFORMANCE REQUIREMENTS DOCUMENT

**LIGHT EMITTING DIODE (LED) LIGHT SOURCES
FOR THE
MEDIUM INTENSITY APPROACH LIGHTING SYSTEM
WITH RUNWAY ALIGNMENT INDICATOR LIGHT (MALSR)**

**GREEN THRESHOLD, PAR-56, LAMP REPLACEMENT
AND
WHITE STEADY BURNING, PAR-38, LAMP REPLACEMENT**

**Lighting Systems Group
Navigation Services Directorate
Technical Operations Services (ATO)**

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1. SCOPE

This document establishes the draft requirements for the Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) Light Emitting Diode (LED) Green Threshold and White Steady Burning Lamp Replacements. These LED lamp replacements will include both visual and infrared emissions. The Green Threshold LED Light Source will be used in the MALSR Threshold as an alternative for the above-ground 300W PAR-56 lamp with a green filter. The White Steady Burning LED Light Source will be used in the MALSR as an alternative for the above-ground PAR-38 lamp. The LED light sources specified in this document will only operate when installed in a MALSR; they will not operate in any other Approach Lighting System.

1.1 Classification

Green Threshold LED Light Source – The non-repairable LRU that interfaces (mechanically and electrically) with the PAR-56 lampholder and emits aviation green colored light. The LED Light source includes the individual LEDs, Circuitry, Light Window, Lens, Electrical Plug, Fastening Mechanism, Enclosure, etc.

White Steady Burning LED Light Source – The non-repairable LRU that interfaces (mechanically and electrically) with the PAR-38 lampholder and emits aviation white colored light. The LED Light source includes the individual LEDs, Circuitry, Light Window, Lens, Electrical Plug, Fastening Mechanism, Enclosure, etc.

1.2 Document Layout

The unique functional requirements for the Green Threshold LED Light Source and the White Steady Burning LED Light Source are documented in sections 3.1 and 3.2 respectively. The functional requirements documented in 3.3 through 3.8 apply to both LED Light Sources.

2. APPLICABLE DOCUMENTS

2.1 General

The following documents form a part of this document and are applicable to the extent specified here. In case of conflict between the documents referenced and the contents of this document, the contents of this document shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.2 Government Documents

2.2.1 Specifications

Source	Number	Title
FAA	FAA-E-982j	PAR-56 Lampholder
FAA	FAA-G-2100H	Electronic Equipment, General Requirements
FAA	FAA-E-2408b	Lamps, PAR-56 Incandescent Aviation Service
FAA	FAA-E-2325 FAA-E-2980	Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR)

2.2.2 Standards

Source	Number	Title
FAA	FAA-STD-019e	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment
Federal	FED-STD-595C(1)	Colors Used in Government Procurement
DoD	MIL-STD-129P(4)	Military Marking for Shipment and Storage
DoD	MIL-STD-810G	Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
DoD	MIL-STD-461F	Requirements for Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

2.2.3 Handbooks

Source	Number	Title
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DoD	MIL-HDBK-781A	Handbook for Reliability Test Methods, Plans, and Environments for Engineering, Development, Qualification, and Production
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2.2.4 Other Government Documents, Drawings, and Publications

Source	Number	Title
FAA	FAA DWG C-6046	Frangible Coupling Type I and Type 1A, Details

2.3 Non-Government Documents

Source	Number	Title
ANSI	ASQ Z1.4-2008	Sampling Procedures and Tables for Inspection by Attributes
ANSI	ESD STM 5.1-2007	Electrostatic Discharge Sensitivity Testing – Human Body Model (HBM) - Component Level
ANSI	ANSLG C81.61-2009	American National Standard for Electrical Lamp Bases
ASTM	D3951	Standard Practice for Commercial Packaging
ASTM	D4169	Standard Practice for Performance Testing of Shipping Containers and Systems
ASTM	E308	Standard Practice for Computing the Colors of Objects Using the CIE System
CIE	S010/E:2004	Photometry – The CIE System of Physical Photometry
CIE	127-2007	Measurement of LEDs
ICAO	Annex 14	Volume I – Aerodrome Design and Operations
IEEE	C62.45-2002	IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits
NFPA	No. 70	National Fire Protection Association, National Electrical Code – 2008
SAE	AS25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for

2.4 Document Sources

2.4.1 Federal and Military Documents

Copies of the above Federal and DoD specifications, standards, and handbooks are available from the Department of Defense Single Stock Point (DoDSSP), 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. Electronic copies of the above Federal and DoD specifications, standards, and handbooks are available from the DoDSSP on the Internet at <http://dodssp.daps.dla.mil>.

2.4.2 Federal Aviation Administration Documents

Electronic copies of some of the above FAA specifications and standards are available on the Internet at <http://www1.faa.gov/asd/standards/index.htm>. Copies of all the above FAA specifications and standards are available by following the *Guide to Federal Aviation Administration Publications*, FAA-APA-PG-10, which is available from the US Department of Transportation (DoT), M-443 .2, Washington, D.C. 20590, Phone: (202) 366-0039 (info only), Fax: (202) 366-3911 (for requests). NOTE: Continue to research for an FAA web link for standards.

FAA drawings may be obtained from:
 FAA William J. Hughes Technical Center
 NAS Documentation Facility, ACK-1
 Atlantic City International Airport
 New Jersey, 08405

2.4.3 National Fire Protection Association (NFPA) Documents

Unless otherwise indicated, copies of the above National Fire Protection Association publications are available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, (800)-344-3555, (617)-770-3000. Electronic copies of the above publications are available on the Internet at <http://www.nfpa.org>.

2.4.4 American Society for Testing and Materials (ASTM) Documents

Unless otherwise indicated, copies of the above American Society for Testing and Materials publications are available from ASTM, 100 Barr Harbor Drive West, PO Box C700, West Conshohocken, PA 19428-2959, (610)-832-9585. Electronic copies of the above publications are available on the Internet at <http://www.astm.org>.

2.4.5 Society of Automotive Engineers (SAE) Documents

Unless otherwise indicated, copies of the Society of Automotive Engineers publications are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001, (877)-606-7323, (724)-776-4841. Electronic copies of the above publications are available on the Internet at <http://www.sae.org>.

2.4.6 International Commission on Illumination (CIE) Documents

Unless otherwise indicated, copies of the International Commission on Illumination publications are available in the United States from Thomson Scientific, 36588 Treasury Center, Chicago, IL 60694-6500, (800)-699-9277. Electronic copies for the above publication are available on the Internet at <http://techstreet.com/ciegate.tmpl>.

2.4.7 Institute of Electrical and Electronics Engineers (IEEE) Documents

Unless otherwise indicated, copies of the Institute of Electrical and Electronics Engineers publications are available from 10662 Los Vaqueros Circle, P. O. Box 3014, Los Alamitos, CA 90720-1264, (800)-272-6657, (714)-821-8380. Electronic copies of the above publications are available on the Internet at <http://www.ieee.org>.

2.4.8 International Civil Aviation Organization (ICAO) Documents

Unless otherwise indicated, copies of the International Civil Aviation Organization are available from: ICAO, Customer Services Unit, 999 University Street, Montreal, Quebec, Canada H3C 5H7, (514) 954-8022. Email: sales@icao.int. Electronic copies of the above publications are available on the Internet at <http://www.icao.int>.

2.4.9 American National Standards Institute (ANSI) Documents

Unless otherwise indicated, copies of the American National Standards Institute publications are available from ANSI, Attn: Customer Service Department, 25 W 43rd Street, 4th Floor, New York, NY 10036, (212)-642-4900, (212)-642-4980. Electronic copies of the above publications are available on the Internet at: <http://www.ansi.org>, <http://www.nssn.org>; and e-mail at: cearl@esda.org (315-339-6937).

3. REQUIREMENTS

The individual requirements for the MALSR Green PAR-56, Threshold LED Light Source are documented in 3.1 and associated subparagraphs. The individual requirements for the MALSR White PAR-38, Steady Burning LED Light Source are documented in 3.2 and associated subparagraphs. All other paragraphs apply to both LED light sources. The LED light sources specified in this document will only operate when installed in a MALSR; they will not operate in any other Approach Lighting System.

3.1 Green Threshold LED Light Source Requirements

3.1.1 General Description

The green threshold LED light source **shall** be a direct replacement for the MALSR above-ground incandescent PAR-56 lamp with a green filter. The green threshold LED light source **shall** interface, mechanically and electrically, with the current PAR-56 lampholder in accordance with (IAW) FAA-E-982 and with the lampholders identified in TABLE III. No modification to the PAR-56 lampholder **shall** be required to install and operate the green threshold LED light source. The green threshold LED light source **shall** properly operate using the existing electrical and control signals provided by the MALSR.

3.1.2 Optical Requirements

The green threshold LED light source **shall** meet all the following requirements over the operating environmental conditions specified in 3.6.1.

3.1.2.1 Beam Pattern

The green threshold LED light source beam **shall** exhibit an elliptical shape defined by the standard ellipse equation:

$$\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$$

where X is the horizontal axis coordinate and Y is the vertical axis coordinate. The outer bounds of the light beam **shall** be no closer than $\pm 6^\circ$ from the optical centerline along the horizontal axis ($a = 6$) and **shall** be no closer than $\pm 4^\circ$ from the optical centerline along the vertical axis ($b = 4$).

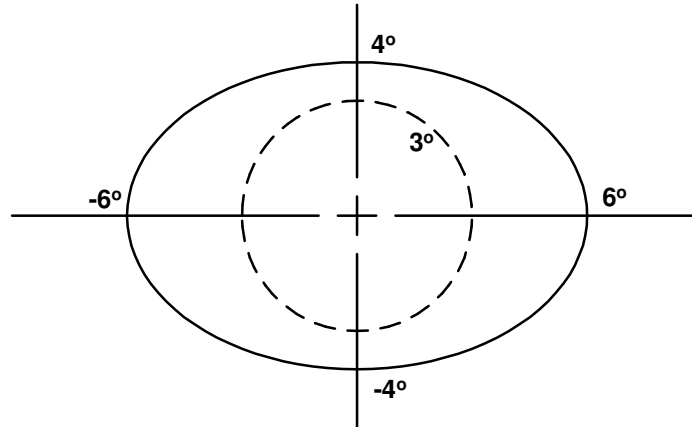


FIGURE 1. Green Threshold Light Source Beam Pattern

3.1.2.2 Average Intensity

The aviation green colored output of the green threshold LED light source **shall** produce three intensity steps that are determined by the input voltage. Within the light beam pattern described in 3.1.2.1, the average intensity **shall** be within the required levels for each intensity step as stated in TABLE I.

TABLE I. Green Threshold Light Source Average Intensity

Average Intensity (Candela)		
Low (4%)	Medium (20%)	High (100%)
200 ± 40	1,000 ± 200	5,000 ± 1,000

3.1.2.3 Intensity Extremes

Within the light beam pattern described in 3.1.2.1, no measured intensity **shall** be less than the minimum allowable intensity listed in TABLE II for each intensity step. Within the light beam pattern described in 3.1.2.1, the maximum measured intensity **shall** be no greater than the maximum allowable intensity listed in TABLE II for each intensity step. The maximum measured light intensity **shall** reside within $\pm 3^\circ$ circle of the light unit centerline (see FIGURE 1).

TABLE II. Green Threshold Light Source Intensity Extremes

Light Source Intensity Extremes (Candela)					
Low (4%)		Medium (20%)		High (100%)	
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
80	360	400	1,800	2,000	9,000

3.1.2.4 Relative Intensity at High Temperatures

The intensity of the green threshold LED light source output at $70^{\circ}\text{C} \pm 2^{\circ}\text{C}$ **shall** be no less than 80% of the intensity at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

3.1.2.5 Chromaticity

The color of the light emitted from the threshold LED light source **shall** be Aviation Green as specified in SAE-AS25050. Within the Aviation Green color specification, the light emitted from the threshold LED light source **shall** have a dominate wavelength less or equal to 530 nanometers (nm) and greater or equal to 500 nm. If multiple LEDs are used within a single threshold light source, each LED **shall** meet both the Aviation Green as specified in SAE-AS25050 and be within the dominate wavelength band.

3.1.2.6 Infrared Requirements

The green threshold LED light source **shall** have an integrated infrared power output greater than 21.0 watts/steradian between 1,300 nm and 1,800 nm or greater than 8.3 W/sr between 3,400 nm and 4,200 nm. The green threshold LED light source infrared beam **shall** be defined by the outer beam pattern in paragraph 3.1.2.1. This is based upon approximately 0.5 watt at the source output in the 1,300 nm to 1,800 nm band and 0.2 watt at the source output in the 3,400 nm to 4,200 nm band focused into the beam pattern in paragraph 3.1.2.1.

3.1.3 Physical Requirements

3.1.3.1 Size

The green threshold LED light source **shall** occupy the available volume allocated to the standard PAR-56 lamp and green filter used in the PAR-56 lampholder. The green threshold LED light source may extend forward beyond where the green filter is mounted.

3.1.3.2 Weight

The green threshold LED light source **shall** weigh no greater than three (3) pounds (lbs).

3.1.3.3 Center of Gravity

The location of the center of gravity for the green threshold LED light source **shall** not adversely affect the ability of the PAR-56 Light Assembly to remain locked at an aiming angle while exposed to the combined wind and rain conditions specified in 3.6.1.6.

3.1.3.4 Vertical Adjustment

The green threshold LED light source **shall** operate over the entire vertical alignment range from 0° horizontal to 10° horizontal. The threshold LED light source **shall** not interfere with the mounting and proper function of the PAR-56 Lampholder Aiming Device. The green threshold LED light source **shall** not interfere with the light assembly vertical alignment process.

3.1.4 PAR-56 Lampholder

The green threshold LED light source **shall** interface and operate properly in the existing PAR-56 Lampholders (see TABLE III) currently installed in the National Airspace System.

TABLE III. PAR-56 Lampholders

Type Number	Manufacturer
FA-9902	Godfrey
FA-11508	NBP/DME

3.1.4.1 PAR-56 Mounting Interface

The green threshold LED light source **shall** be mounted into the PAR-56 lampholder using the existing lamp clip mechanism IAW FAA-E-982j paragraph 3.3.1.2.

3.1.4.2 PAR-56 Electrical Interface

The green threshold LED light source **shall** have a Mogul End, Straight Prong connector IAW FAA-E-2408b paragraph 3.6.4.

3.1.5 Power Demand

The average wattage rating of the green threshold LED light source **shall** be no greater than 45 watts (W), with a goal of 30W.

3.2 White Steady Burning LED Light Source Requirements

3.2.1 General Description

The white steady burning LED light source **shall** be a direct replacement for the MALSR above-ground incandescent PAR-38 lamp. The white steady burning LED light source **shall** interface, mechanically and electrically, with the current PAR-38 lampholders specified in TABLE V. No modification to the PAR-38 lampholder **shall** be required to install and operate the white steady burning LED light source. The white steady burning LED light source **shall** properly operate using the existing electrical and control signals provided by the MALSR.

3.2.2 Optical Requirements

The white steady burning LED light sources **shall** meet all the following requirements over the operating environmental conditions specified in 3.6.1.

3.2.2.1 Beam Pattern

The white steady burning LED light beam pattern **shall** be circular in shape (shown in FIGURE 2) along the optical centerline of the LED light source. The outer bounds of the main-beam pattern **shall** be no closer than $\pm 8^\circ$. The full width half maximum shall be $\pm 8^\circ$

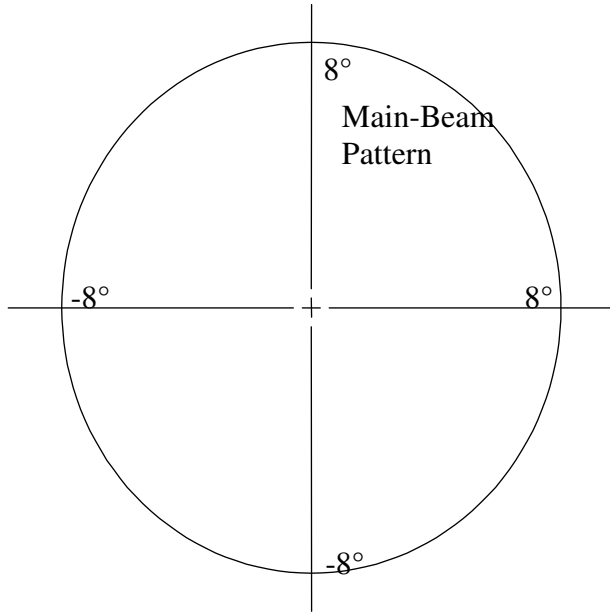


FIGURE 2. White Steady Burning Light Source Beam Pattern

3.2.2.2 Average Intensity

The aviation white output of the steady burning LED light source **shall** produce three intensity steps that are determined by the input voltage. Within the beam pattern described in 3.2.2.1, the average intensity **shall** be within the required levels as stated in TABLE IV.

TABLE IV. White Steady Burning Light Source Average Intensity

Pattern	Steady Burning Average Intensity (Candela)		
	Low (4%)	Medium (20%)	High (100%)
Main Beam ($\pm 8^\circ$)	400 ± 60	$2,000 \pm 300$	$10,000 \pm 1500$

3.2.2.3 Intensity Extremes

Within the main-beam ($\pm 8^\circ$), no measured intensity point **shall** be greater than 12,000 Candela.

3.2.2.4 Relative Intensity at High Temperatures

The intensity of the white steady burning LED light source output at $70^\circ\text{C} \pm 2^\circ\text{C}$ **shall** be no less than 80% of the intensity at $25^\circ\text{C} \pm 2^\circ\text{C}$.

3.2.2.5 Chromaticity

The color of the light emitted from the steady burning LED light source **shall** be Aviation White as specified in SAE-AS25050. Within the Aviation White color specification, the light emitted from the steady burning LED light source **shall** have a color temperature less or equal to 4500K and greater or equal to 2750K. If multiple LEDs are used within a steady burning light source, each element **shall** meet both the Aviation White as specified in SAE-AS25050 and be within the color temperature band.

3.2.2.6 Infrared Requirements

The white steady burning LED light source **shall** have an integrated infrared power output greater than 8.2 watts/steradian between 1,300 nm and 1,800 nm or greater than 3.3 W/sr between 3,400 nm and 4,200 nm. The white steady burning LED light source infrared beam **shall** be defined by a $\pm 8^\circ$ beam pattern along the optical centerline of the LED light source. This is based upon approximately 0.5 watt at the source output in the 1,300 nm to 1,800 nm band and approximately 0.2 watt at the source output in the 3,400 nm to 4,200 nm band focused into the beam pattern in paragraph 3.2.2.1.

3.2.3 Physical Requirements

3.2.3.1 Size

The white steady burning LED light source **shall** occupy the available volume allocated to the standard PAR-38 lamp used in the PAR-38 lampholder.

3.2.3.2 Weight

The white steady burning LED light source **shall** weigh no greater than two and a half (2.5) lbs. with a goal of one and a half (1.5) lbs.

3.2.3.3 Center of Gravity

The location of the center of gravity for the white steady burning LED light source **shall** not adversely affect the ability of the PAR-38 Light Assembly to remain locked at an aiming angle while exposed to the combined wind and rain conditions specified in 3.6.1.6.

3.2.3.4 Vertical Adjustment

The white steady burning LED light source **shall** operate over the entire vertical alignment range from 0° horizontal to 10° horizontal. The white steady burning LED light source **shall** not interfere with the mounting and proper function of the PAR-38 Lampholder Aiming Device. The white steady burning LED light source **shall** not interfere with the light assembly vertical alignment process.

3.2.4 PAR-38 Lampholder

The white steady burning LED light source **shall** interface and operate properly in the existing PAR-38 Lampholders (see TABLE V) currently installed in the National Airspace System.

TABLE V. PAR-38 Lampholders

Type Number	Manufacturer
FA-10290/5	AVW
FA-11506	DME
FA-10267/5	Godfrey
FA-10097/5	Godfrey
FA-9877 Unit-3	Multi-Electric
FA-9426/3	Multi-Electric
FA-8767/LH	Multi-Electric
FA-8091/LH	Multi-Electric
FA-9629/3	SEPCO

3.2.4.1 PAR-38 Interface

The white steady burning LED Light Sources **shall** have a Medium Screw, Skirted Base (E26) IAW ANSI/IEC C81.61.

3.2.5 Power Demand

The average wattage rating of the white steady burning LED light source **shall** be no greater than 45W, with a goal of 30W.

3.3 Electrical Requirements

Unless otherwise specified, all circuitry, wiring, and enclosures **shall** meet National Fire Prevention Association (NFPA) 70 National Electric Code requirements.

3.3.1 Electrical Power

3.3.1.1 Input Voltage

The LED light source **shall** produce three light intensities at three discrete input line voltages as described in TABLE VI.

TABLE VI. Input Voltage

Intensity Level	Light Intensity	Input Voltage
Low	4%	50 VAC
Medium	20%	75 VAC
High	100%	120 VAC

3.3.1.2 Input Frequency

The LED light source **shall** accept input power at a frequency of 60 Hertz (Hz). The LED light source **shall** not be damaged or experience performance degradation with steady state or momentary deviation in input frequency as specified in Paragraph 3.1.1.7c of FAA-G-2100h.

3.3.1.3 Voltage Harmonic Distortions

The LED light source **shall** not produce voltage harmonic distortions as specified in Paragraph 3.1.1.7d of FAA-G-2100h.

3.3.1.4 Voltage Variation

The LED light source **shall** operate properly and not be damaged by voltage variations of $\pm 2.5\%$ VAC at each intensity level.

3.3.1.5 Current Harmonic Distortions

The LED light source **shall** not produce current harmonic distortions as specified in Paragraph 3.1.1.5 of FAA-G-2100h.

3.3.1.6 Power Factor

The LED light source power factor shall be IAW 3.1.1.3.1 of FAA-G-2100h.

3.3.2 Power Interface Protection

3.3.2.1 Power Line Surges

Power interfaces for the LED light source **shall** be protected and not be damaged from any power line surges as specified in FAA-STD-019e, Paragraph 4.2.2.

3.3.2.2 Power Transients

The power interfaces for the LED light source **shall** provide conducted line transient protection as specified in FAA-STD-019e, Paragraph 4.2.2.1. The LED light source **shall** be operational when exposed to a combination waveform consisting of a 1.2/50 μ s voltage spike at 10kV and an 8/20 μ s current spike at 10kA.

3.3.2.3 Power Outages

The LED light source performance **shall** not be damaged by MALS facility power outage conditions. Any solid-state devices within the LED light source **shall** remain active for 100 ms following a power interruption to avoid an inadvertent light source outage. The LED light source **shall** automatically reset, if necessary, on power restoration in the event of a power interruption.

3.3.3 Response Time

The LED light source driver circuit **shall** respond to an intensity step change in less than one (1) second after receiving the change of input voltage.

3.3.4 Grounding

Electrical grounding for the LED light source **shall** be IAW with the National Electric Code as outlined in FAA-STD-019e Paragraphs 4.2.10 and 4.3.4.

3.3.5 Bonding

Electrical bonding for the LED light source **shall** be IAW FAA-STD-019e Paragraph 4.1.1.

3.3.6 Shielding

Electrical shielding for the LED light source **shall** be IAW FAA-STD-019e Paragraph 4.1.2.

3.3.7 Lightning Protection

Lightning Protection for the LED light source **shall** be IAW FAA-STD-019e Paragraph 4.2.3.

3.4 Electromagnetic Interference (EMI) Requirements

3.4.1 Conducted Emission Interference

The LED light source **shall** meet the Conducted Emission Interference requirements of CE102 specified in MIL-STD-461F with a frequency range of 10 kHz to 10 MHz.

3.4.2 Radiated Emission Interference

The LED light source **shall** meet the Radiated Emission Interference requirements of RE102, Figure RE102-4 for ground application, specified in MIL-STD-461F with the exception that the frequency range tested shall be 2 MHz to 10 GHz.

3.4.3 Conducted Susceptibility

The LED light source **shall** meet the Conducted Susceptibility requirements of CS114 specified in MIL-STD-461F. The frequency range **shall** be 10 kHz to 200 MHz, and Curve #2 of Figure CS114-1 of MIL-STD-461F shall be used for the limit IAW Table III for Navy ground equipment.

3.4.4 Radiated Susceptibility

The LED light source **shall** meet the Radiated Susceptibility requirements of RS103 defined in MIL-STD-461F. The frequency range **shall** be 2 MHz to 18 GHz. The electric field intensity **shall** be IAW the limits for Navy ground equipment to Table VII RS103 limits for Navy ground equipment of MIL-STD-461F.

3.5 Electrostatic Discharge (ESD) Protection

The LED light source **shall** provide ESD protection to reduce the frequency of ESD events and to minimize the effects as outlined in FAA-STD-019e paragraph 4.3.7. All

electronic circuitry that contain miniaturized or solid-state components **shall** be considered ESD susceptible.

3.6 Environmental Requirements

3.6.1 Operational Environmental Requirements

The LED light source **shall** operate continuously and intermittently under the environmental conditions specified. The LED light source **shall** be capable of performing satisfactorily under the conditions specified in Paragraph 3.2.1.1.2 of FAA-G-2100h for common outdoor operating environmental conditions except where the requirements in the following subsections differ.

3.6.1.1 Temperature

The LED light source **shall** exhibit no adverse effects during operation at temperature ranges at all specified climate categories in Table C-1 of MIL-STD-810F.

3.6.1.2 Humidity

The LED light source **shall** exhibit no adverse effects during operation at relative humidity levels over all climate categories defined in Table C-1 of MIL-STD-810F.

3.6.1.3 Altitude

The LED light source **shall** exhibit no adverse effects during operations at an altitude range from -300 feet to 10,000 feet as specified in FAA-G-2100h.

3.6.1.4 Sand and Dust

The LED light source **shall** exhibit no adverse effects during exposure to wind blown sand and dust particles of 5,700 feet/minute (ft/min) (29 meters/second (m/s)) and 1,750 ft/min (8.9 m/s) respectively.

3.6.1.5 Salt Spray

The LED light source **shall** operate under exposure to salt-laden atmosphere with relative humidity as stated in 3.6.1.2.

3.6.1.6 Combined Rain and Wind

The LED light source **shall** operate under exposure to wind blown rain at rain rates up to 4 inches/hour and wind velocities up to 40 miles per hour (mph).

3.6.1.7 Thermal Shock

The LED light source **shall** withstand exposure of external surfaces (including the light window) to a sudden application of cold (0° C to 5° C) water when the light source reaches stable temperatures in the high intensity mode.

3.6.1.8 Solar Radiation (Sunshine)

The LED light source **shall** operate under exposure to sunshine as specified for all climate categories as defined in Table C-1 of MIL-STD-810F using the spectral energy distribution in Table 505.4-I.

3.6.1.9 Vibration

The LED light source installed in the lampholder **shall** be capable of withstanding vibrations as defined by Figure 514.5C-14 in MIL-STD-810F using the parameters presented in TABLE VII.

TABLE VII. Vibration Profile Parameters

Parameter	Value
W_1	0.08 [g^2/Hz]
W_2	0.022 [g^2/Hz]
f_1	220 Hz
f_2	1220 Hz

3.6.1.10 Ice Accumulation

The energized LED light source **shall** prevent the accumulation of ice on the face of the light source when exposed to an ambient air temperature of $-10^{\circ}C \pm 2^{\circ}C$ and water droplet temperature of $0^{\circ}C$ to $3^{\circ}C$.

3.6.2 Non-operating Environmental Requirements

The LED light source **shall** not be damaged when stored or transported under conditions delineated in the non-operating conditions specified in Paragraph 3.2.1.2 of FAA-G-2100h.

3.7 Reliability and Maintainability Requirements

3.7.1 Reliability

The LED light source Mean Time Between Failures (MTBF) **shall** be greater than 50,000 hours. The LED light source is considered “failed” once the visible or infrared output has degraded beyond 70 percent of its original output or when 25 percent of the emitters in the light source have failed to emit light.

3.7.2 Maintainability

The LED light source **shall** be a “throw-away” Line Replaceable Unit (LRU). No preventive maintenance on the LED light source **shall** be required. The LED light source **shall** be replaced and be operational in less than 5 minutes.

3.8 Interoperability

The LED light source **shall** interface and operate properly, at each intensity step, in existing MALSRs (see Table VIII) installed in the National Airspace System.

Table VIII - MALSR Systems

MALSR Type Number	Manufacturer
FA-17900	DME
FA-11500	DME
FA-10290	AVW
FA-10267	Godfrey
FA-10098	Godfrey
FA-10097	Godfrey
FA-9994	Multi-Electric
FA-9877	Multi-Electric
FA-9629	SEPCO
FA-9425	Multi-Electric
FA-8981	Sylvania
FA-8767	Multi-Electric
FA-8091	Multi-Electric

3.9 Design & Construction Requirements

3.9.1 Fungus-proof Materials

Materials that are nutrients for fungi **shall** not be used.

3.9.2 Ultra-Violet Protection

Materials that degrade or deteriorate when subjected to ultra-violet radiation **shall** be protected with the appropriate coating.

3.9.3 Metals

Metals used in the housing of the LED light source **shall** be compatible with the material used in their respective lampholder. Metals **shall** be corrosion resistant or be suitably treated to resist oxidation and environmental conditions (see 3.6) that may be encountered in storage and normal service.

3.9.4 Exterior Coating

Metal surfaces of the LED light source that extend beyond the lampholder **shall** be painted Aviation Orange IAW FED-STD-595B.

3.9.5 Thermal Design

The thermal design of the LED light sources **shall** ensure that the maximum temperature of the heat sink on which the LED array is mounted is 20°C less than the manufacturers' maximum rated junction temperature for the LED during full current (high intensity) operation in a total (ambient, solar radiation) heat load of 70°C. The thermal design of the LED light sources **shall** direct heat dissipation through the light window to help prevent ice accumulation.

3.9.5.1 Heating Device

The lamp shall be provided with a thermostatically controlled heater to prevent the formation of ice on the face plate when in accordance with 4.4.2.10.

3.9.6 Internal Condensation

The LED light source design **shall** prevent internal condensation and accumulation of moisture.

3.9.7 Marking

Each LED light source **shall** be marked in the back with:

Ordering Designation,

Serial Number,

Average Intensity,

LED Dominant Wavelength Bin,

LED Luminous Intensity (flux) Bin

LED Forward Voltage Bin,

Day, Month, and Year of Manufacture, and

Manufacturer's Name, Logo, Trademark, or Cage Number.

The marking **shall** be permanent and remain legible for the life of the light source. Stick on labels shall not be used.

3.9.8 Workmanship

Each LED light source **shall** be free of blemishes and defects. Soldering, welding, brazing, cementing, and wiring **shall** be thorough. Alignment of parts **shall** be accurate. The mogul end prongs **shall** be straight, without bends, twists, or burrs. The LED light source **shall** be free of loose internal items and debris.

3.9.9 Cleaning

Each LED light source **shall** be thoroughly cleaned. Loose, spattered or excess solder, metal chips, flux, and other foreign material **shall** be removed during and after final assembly of the LED light source.

4. VERIFICATION

4.1 Design Qualification Test

The first twenty five (25) green threshold LED light source units and the first fifty (50) white steady burning LED light source units manufactured shall be designated as the design qualification units. The design qualification units shall be subjected to qualification tests specified in Section 4.4, as required by the Requirements Verification Traceability Matrix in Appendix A, and the Reliability Demonstration Test as specified in 4.1.1. The LED light source units used in the design qualification tests shall not be a part of the FAA procurement quantity.

4.1.1 Reliability Demonstration

The reliability demonstration of the LED light source design qualification units shall be performed to verify conformance to the requirements in FAA-G-2100h Section 3.2.3. If the reliability demonstration does not require interruption of the 150-hour test (see 4.4.11.1), then both tests may be performed concurrently. Reliability Demonstration Tests shall be IAW MIL-HDBK-781 Paragraph 4 and Test Plan XXI-D. All LED light source equipment shall be subjected to the test conditions of MIL-HDBK-781, Paragraph 4.3, except that no vibration conditions need be imposed. Equipment shall be duty cycled IAW 4.4.11.2 on a daily basis.

4.1.2 Maintainability Demonstration

The maintainability demonstration of the LED light source design qualification units shall be performed to verify the elapsed time to replace a LED light source in a PAR-56 lampholder and a PAR-38 lampholder.

4.2 Production Acceptance Test

Testing of the production units shall start after the design qualification test (see 4.1) is completed and accepted by the FAA. Tests on production units shall be as specified in 4.4, as required by the Requirements Verification Traceability Matrix in Appendix A. Acceptance shall be made on a sampling basis IAW ANSI/ASQC Z1.4-1993, using Special Inspection Level S-3, AQL 4.0 and a single sampling plan for normal inspection as per Table II-A.

4.3 24-Hour Burn-In

All LED light sources shall complete a 24-hour burn-in before any testing is started. The LED light sources shall operate for 24-hours on high intensity at room temperature ($25^{\circ}\text{C} \pm 10^{\circ}\text{C}$).

4.4 Test Procedures

4.4.1 Visual Inspection

The LED light source shall be visually inspected for workmanship, fabrication, finishing, painting, and adequacy of selected parts as required in FAA-G-2100h Paragraphs 3.1.2,

3.2.2, and 3.3 as applied according to the Requirements Verification Traceability Matrix in Appendix B.

4.4.2 Environmental Tests

Upon completion of each of the environmental tests defined in 4.4.2.1 through 4.4.2.10, the LED light source shall undergo at least one operational test cycle specified in 4.4.11.1 (steps 1 through 6). The procedure for environmental testing shall be in compliance with Paragraphs 4.2.2.8 and 4.2.2.9 of FAA-G-2100h. Unless otherwise noted, the LED light source shall be tested while installed in its lampholder and operating on high intensity.

4.4.2.1 Temperature Test

The procedure for temperature testing shall be IAW Procedure I (non-operating) and Procedure II (operating) of Method 501.4 and Method 502.4 of MIL-STD-810F. The Environmental Tests for the photometric requirements of the LEDs outlined in 4.4.3 may also be performed at this time.

4.4.2.2 Humidity Test

The procedure for humidity testing shall be IAW Method 507.4 of MIL-STD-810F.

4.4.2.3 Altitude Test

The altitude test shall be IAW Procedure I and Procedure II, Method 500.4 of MIL-STD-810F. The operation portion of the test shall be completed after holding the equipment at the low pressure for one (1) hour. Equipment shall be tested at atmospheric pressure corresponding to -300 feet and 10,000 feet altitude at both operating temperature extremes. Procedure I shall use the non-operating system requirement values in Section 3.3.2. The altitude test and the temperature test (see 4.4.2.3) shall be combined.

4.4.2.4 Sand and Dust Test

The sand and dust tests shall be IAW Procedures I and II, Method 510.4, of MIL-STD-810F. The air velocities used in the sand and dust test shall be 5,700 ft/min and 1,750 ft/min, respectively. The test durations shall be six (6) hours each and the equipment shall be rotated twice during the conduct of each test.

4.4.2.5 Salt Fog Test

The salt spray test shall be IAW MIL-STD-810F, Method 509.4. The equipment shall be exposed for two 48-hour cycles of exposure and drying. One cycle consists of a 24-hour period of salt exposure followed by 24 hours of drying. Do not remove salt accumulation during the first drying period. At the conclusion of the test, salt build-up may be removed with tap water.

4.4.2.6 Wind and Rain Test

The rain test shall be IAW Procedure I, Method 506.4 of MIL-STD-810F. The wind velocity shall be 40 mph, and the rainfall rate shall be 4 in/h. The test item temperature

shall be at least $10^{\circ}\text{C} \pm 3^{\circ}\text{C}$ higher than the rain temperature at the beginning of each 30-minute exposure period.

4.4.2.7 Thermal Shock Test

The LED light source shall be installed as in normal use and operated at high intensity until the temperature has stabilized. At least 3 gallons of water at a temperature of 0°C to 5°C shall be sprayed on the top surface. There shall be no cracking of glass or metal and the units shall be operational during this test.

4.4.2.8 Solar Radiation (Sunshine) Test

The solar radiation test shall be IAW MIL-STD-810F, Procedure II, Method 505.4. The test shall be conducted for a total of fifty six (56) cycles.

4.4.2.9 Vibration Test

The LED light source units and their respective lampholders shall be vibration tested using the 3-axis version of Procedure 514.5 in MIL-STD-810F. The lampholder will be mounted on Electrical Metallic Tubing, 14 inches long, with the frangible coupling mounted to the vibration test apparatus. After the vibration test, the LED light source shall be thoroughly examined for all damage including, but not limited to, mechanical failure of any component, loosening of any part, cracked or broken seals, continuity of electrical circuits, and possible damage to the light source. The LED light source shall be retested following the vibration test for compliance with the photometric requirements.

4.4.2.10 Ice Accumulation Test

The LED light source shall operate while subject to the conditions specified in 3.6.1.10 using the Procedure I, Method 521.2 of MIL-STD-810F and tailored as follows. The LED light source shall be placed in an environment with the front of the LED light source angled at $+25^{\circ}$ to the horizontal, facing the water dispenser and with an air temperature of $-10^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The air temperature shall be stabilized at -10°C for 2 hours. The LED light source shall then be turned ON in high intensity and left to stabilize for 2 hours while keeping the air temperature constant at -10°C . Water shall then be introduced by suitable means at a temperature of 0°C to $+3^{\circ}\text{C}$. Water droplet size shall be 1 to 1.5 mm in diameter. The water density shall be 5.5 ± 1 gram/cubic centimeter (g/cm^3). The water delivery rate shall be 25 ± 2 millimeters/hour (mm/hr) with the exposure time being four (4) hours. No ice shall be allowed to accumulate on the face of the LED light source.

4.4.3 Photometric Tests

All Intensity measurements shall be made according to a 0.5° rectangular grid (similar to Figure 2-11 of ICAO 1999 Annex 14). The photometric tests shall be modified in conformance to the guidelines in CIE-127-2007 to derive photometric parameters equivalent to those of other light sources. The tests shall be conducted on the complete array mounted in the fixture, not the individual LEDs. The LEDs test apparatus shall be calibrated using a LED reference standard as described in Paragraph 2.2.2 of CIE-127-2007. Unless otherwise stated, the measurement of the intensity shall be done

using a goniophotometer with a distance between the LED light source and the detector at a minimum of sixty (60) feet.

The tests shall be performed for all combinations of specified operational input voltages and fluctuations. Unless otherwise specified, all tests shall be performed at room temperature ($25^{\circ}\text{C} \pm 10^{\circ}\text{C}$).

4.4.3.1 Green Threshold LED Light Source Tests

All green threshold LED light sources units shall incorporate a 60-minute warm-up period.

4.4.3.1.1 Beam Pattern Test

Intensity, in Candela, shall be measured at each of the grid-points described in 4.4.3 within the beam pattern of $\pm 10^{\circ}$ in all directions. The grid point intensities for the green threshold LED light source shall be measured at all three (3) intensity steps: Low, Medium, and High.

4.4.3.1.2 Intensity Test

The minimum grid point intensity measured from the Beam Pattern Test on the green threshold LED light source (see 4.4.3.1.1), shall be no less than the minimum allowable intensities stated in TABLE II. The maximum grid point intensity shall reside within $\pm 3^{\circ}$ circle of the LED light source unit centerline and shall be less than the maximum allowable intensities stated in TABLE II.

4.4.3.1.3 Average Intensity Test

The green threshold LED light source average intensity shall be calculated as the arithmetic mean of all intensities measured at the grid-points (see 4.4.3.1.1) during the Beam Pattern Test. The Average Intensity shall reside within the maximum and minimum allowable intensities specified in TABLE II. Average intensity shall be calculated for all three (3) intensity steps: Low, Medium, and High.

4.4.3.1.4 Relative Intensity Test at Temperature Extremes

The green threshold LED light source mounted in a PAR-56 Lampholder shall be installed and operating properly within a thermal test chamber. The output of the LED light source shall be directed through a diffuser mounted on the thermal chamber's window. While operating on high intensity step, the defused intensity of the green threshold LED light source shall be measured at room temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$) and at high temperature ($70^{\circ}\text{C} \pm 2^{\circ}\text{C}$). The test results shall prove that the intensity at high temperature is no less than 80% of the intensity at room temperature. The photometric measurements shall be taken once the temperature has stabilized for two (2) hours.

4.4.3.1.5 Chromaticity Test

The green threshold LED light source shall conform to the aviation green color and dominate wavelength requirements defined in 3.1.2.5. The chromaticity test shall use the CIE system defined in CIE DS 010.2 and ASTM E308-01 using the test procedures in Paragraph 4 of SAE AS25050. This chromaticity test shall be performed at all three (3) operating intensity levels.

4.4.3.2 White Steady Burning LED Light Source Tests

All white steady burning LED light source units shall incorporate a 60-minute warm-up period.

4.4.3.2.1 Beam Pattern Test

Intensity, in Candela, shall be measured at each of the grid-points described in 4.4.3, within the beam pattern of $\pm 15^\circ$ in all directions. The grid point intensities for the white steady burning LED light source shall be measured at all three (3) intensity steps: Low, Medium, and High.

4.4.3.2.2 Intensity Test

The maximum grid point intensity measured from the beam pattern test on the white steady burning LED light source (see 4.4.3.2.1), the main-beam shall be less than the corresponding maximum allowable intensity stated in 3.2.2.3.

4.4.3.2.3 Average Intensity Test

The white steady burning LED light source average intensity shall be calculated for the main beam pattern only. The average intensity shall be calculated as the arithmetic mean of all intensities measured at the grid-points within the main beam pattern during the Beam Pattern Test. The average intensity shall reside within the maximum and minimum allowable intensities specified in TABLE IV. Average Intensity shall be calculated for all three (3) intensity steps: Low, Medium, and High.

4.4.3.2.4 Relative Intensity Test at Temperature Extremes

The white steady burning LED light source mounted in a PAR-38 lampholder shall be installed and operating properly within a thermal test chamber. The output of the LED light source shall be directed through a diffuser mounted on the thermal chamber's window. While operating on high intensity, the defused intensity of the white steady burning LED light source shall be measured at room temperature ($25^\circ\text{C} \pm 2^\circ\text{C}$) and at high temperature ($70^\circ\text{C} \pm 2^\circ\text{C}$). The test results shall prove that the intensity at high temperature is no less than 80% of the intensity at room temperature. The photometric measurements shall be taken once the temperature has stabilized for two (2) hours.

4.4.3.2.5 Chromaticity Test

The white steady burning LED light source shall conform to the aviation white color and color temperature requirements defined in 3.2.2.5. The chromaticity test shall use the CIE system defined in CIE DS 010.2 and ASTM E308-01 using the test procedures in

Paragraph 4 of SAE AS25050. This chromaticity test shall be performed at all three (3) operating intensity levels.

4.4.3.3 Infrared Radiation Test

The spectral irradiance measurements of the LED light source, at each intensity step, shall be made over the wavelength of 1,000 nm to 5,000nm in 50 nm increments. All spectral irradiance measurements shall be made according to a 0.5° rectangular grid (similar to Figure 2-11 of ICAO 1999 Annex 14) within the beam pattern of $\pm 8^\circ$ in all directions. All LED light source units shall incorporate a 60-minute warm-up period before testing. While operating on High Intensity, the integrated infrared power output for the applicable wavelength band shall exceed the value specified in 3.1.2.6 or 3.2.2.6. The spectra-radiometric system shall be calibrated prior to any measurement. All data measurements shall be traceable to NIST Standards.

4.4.4 Electrical Tests

Unless otherwise noted, the LED light source shall be tested while installed in its lampholder and operating on high intensity.

4.4.4.1 General Electrical Characteristic Test

The LED light source units shall be tested to the FAA-G-2100h requirements stated below.

4.4.4.2 Power Interruption Test

Tests shall be performed with the LED light sources operating at the high intensity level. The LED light sources shall restart automatically and in the same state of service before the interruption or shutdown is experienced due to the surges or transients. The LED light source shall still be active 100 ms after the interruption. This test shall be performed using a digital oscilloscope.

4.4.4.3 Voltage Variation Test

This test shall be performed using a variable transformer that will test the line voltage and the voltage variation extremes for each of the input voltages specified in TABLE VI. The average intensity of the LED light source shall be within the specified range (see 3.1.2.2 or 3.2.2.2) at the line voltage and at the voltage variation extremes specified in 3.3.1.4.

4.4.4.4 Voltage Harmonic Test

This test shall be performed using a line power analyzer to measure the voltage harmonic distortion at the input of the LED light source. Measurement shall be taken for each of the input voltages specified in TABLE VI. The results shall meet the requirements in 3.3.1.3

4.4.4.5 Current Harmonic Test

This test shall be performed using a line power analyzer to measure the current harmonic distortion at the input of the LED light source. Measurement shall be taken for each of the input voltages specified in TABLE VI. The results shall meet the requirements in 3.3.1.5

4.4.4.6 Power Factor Test

This test shall be performed using a line power analyzer to measure the power factor at the input of the LED light source. Measurement shall be taken for each of the input voltages specified in TABLE VI. The results shall meet the requirements in 3.3.1.6.

4.4.4.7 Power Line Surge Test

Power line surge protection shall be verified IAW IEEE C62.45. The 1.2/50 μ s – 8/20 μ s voltage/current waves at 20 KV and 10 KA ($\pm 10\%$) respectively shall be coupled into all internal and external power interfaces. The LED light source shall maintain normal operation through the application of a minimum of five (5) test surges per line.

4.4.4.8 Input Power Voltage/Time Events Tests

The LED light source electrical interface shall be tested for the voltage/time events as defined by the “Federal Aviation Administration Input Power Tolerance Envelope” described in Appendix 1 of FAA-G-2100h. Each 120 VAC leg of the input shall be tested for all conditions with the exception of FAA-G-2100h, Paragraph 3.4 (High-Frequency Impulse and Ringwave) and Paragraph 3.8 (Prohibited Region). The LED light source shall maintain normal operation during voltage/time event application except where indicated otherwise.

4.4.4.9 Power Consumption Test

The LED light source power demand shall be tested at the terminal inputs on the lampholder while the LED light source is operating on high intensity.

4.4.4.10 LED Circuitry Temperature Test

Because the LED circuitry temperature cannot be measured directly, the LED light source shall be tested with a thermistor in good thermal contact with the heatsink on which the LED circuit is mounted. The center of the LED array mounting plate temperature shall meet the temperature requirements in 3.9.5 when operating on high intensity.

For the design qualification test, the heatsink temperature will be measured during the Solar Radiation Test (see 4.4.2.8). For the production acceptance test, the heatsink temperature will be measure after being exposed for six (6) hours at 70°C, then operating on high intensity for two (2) hours.

4.4.4.11 Electromagnetic Interference Tests

The LED light source shall be connected, as it would be operationally. Measurement of the conducted emission levels shall be IAW test method CE102 of MIL-STD-461F. Measurement of the conducted susceptibility shall be IAW test method CS114 of MIL-STD-461F. Measurement of the radiated emissions shall be IAW test method RE102 of MIL-STD-461F. Measurement of the radiated susceptibility shall be IAW test method RS103 of MIL-STD-461F.

4.4.4.12 Electrostatic Discharge Test

The LED light source shall withstand a static discharge of 15,000 volts IAW ANSI/ESD STM 5.1

4.4.4.13 Grounding and Bonding Test

The isolation shall be 10 Mega-ohms or greater. All bonds shall be measured with a 4-terminal milli-ohmmeter. The bonds shall have a maximum resistance of 1 milliohm.

4.4.5 LED Light Source Weight Test

Using a digital scale with an accuracy of 0.1 lbs, the LED light source shall be weighed. The LED light source shall not exceed the applicable weight requirements.

4.4.6 Aiming Device and Aiming Angle Test

With the LED light source mounted in its lampholder, the aiming device shall be attached. The LED light source shall not interfere with the mounting of the aiming device. The light assembly (LED light source and lampholder) shall be aimed at 0°, 3°, 5°, 10°, 15°, 20°, and 25°.

4.4.7 Pulse Repetition Rate Test

If Pulse Width Modulation is implemented, measure the pulse repetition rate of the LED light source either electrically or optically. The pulse repetition rate shall be greater than 120 Hz.

4.4.8 PAR-56 Interoperability Test

The green threshold LED light source shall be mounted into each of the PAR-56 lampholders specified in TABLE III. The LED lamp shall be activated for one (1) minute on each intensity level.

4.4.9 PAR-38 Interoperability Test

The white steady burning LED light source shall be mounted into each of the PAR-38 lampholders specified in TABLE V. The LED lamp shall be activated for one (1) minute on each intensity level.

4.4.10 MALSR System Interoperability Test

The green threshold LED light source and the steady burning white LED light source shall be mounted into each of the MALSR systems defined in Table VIII and operated on all intensity steps.

4.4.11 Operational Tests

All operating requirements of the LED light sources shall be checked over the full range of voltage input variations.

4.4.11.1 150-Hour Test

A 150-hour continuous operation shall be performed on the design qualification units (10 green threshold LED light sources and 10 white steady burning light sources) at ambient temperature $25^{\circ}\text{C} \pm 10^{\circ}\text{C}$. All intensity steps shall be checked by cycling the system as follows:

1. Low intensity on for 5 ± 1 minutes,
2. Off for 2 seconds maximum,
3. Medium intensity on for 5 ± 1 minutes,
4. Off for 2 seconds maximum,
5. High intensity on for 5 ± 1 minutes,
6. Off for 60 ± 10 seconds,
7. Repeat cycle for 50 hours, starting with step 1,
8. Low intensity on for 5 ± 0.2 seconds,
9. Medium intensity on for 5 ± 0.2 seconds,
10. High intensity on for 5 ± 0.2 seconds,
11. Off for 17 ± 3 seconds,
12. Repeat cycle for 100 hours, starting with step 8.

During the first ten (10) cycles, the LED light source response time to intensity step changes shall be measured.

When a failure is detected (Contractor test equipment generated) during the conduct of the test, the test shall be discontinued and the cause of the failure investigated. The test shall start over only after the failure has been corrected.

4.4.11.2 Two-Hour Test

The LED light source production units shall undergo a 2-hour continuous operational test IAW step 1 through 6 of 4.4.11.1. The 2-hour test shall be performed at ambient temperature conditions ($25^{\circ}\text{C} \pm 10^{\circ}\text{C}$).

4.5 Test Instruments

The manufacturer or the subcontracted testing laboratory performing the system tests shall provide adequate instrumentation for these tests as specified in FAA-G-2100h, Paragraph 4.2.3.

In addition, all instruments shall have documentation of its calibration within the six (6) months preceding the tests. Oscilloscopes and photometric equipment shall be calibrated every three (3) months during the test period. Alternating current instruments shall be true root mean squared.

Temperature sensing elements shall be thermocouple. Each thermocouple shall be pre-tested by inserting it into a chamber of known temperature. The thermocouple shall be installed at points determined by the FAA representative. The thermocouples shall be secured in place with high temperature cement manufactured for this purpose.

5. PACKAGING

5.1 General

Each LED light source **shall** be packaged for extended warehouse storage and reshipment. Packaging **shall** be IAW ASTM D 3951 and testing **shall** be IAW ASTM D 4169, Assurance level II, Distribution Cycle 18.

5.2 Packaging

Each LED light source, with one (1) inch cushioning on all sides, **shall** be packaged in an individual (unit package) fiberboard container. Unit packages **shall** be packed in intermediate containers with 12 unit packages per container. Packaging, intermediate packaging, and shipping containers **shall** be capable of multiple handling and storage cycles under favorable conditions, such as enclosed facilities, for a minimum of one year.

5.2.1 ESD Packaging

Each LED light source **shall** be enclosed in an anti-static/ESD bag. The ESD bag **shall** protect the LED light source from ESD damage during shipping and storage.

5.3 Palletized Shipments

All palletized shipments **shall** be made on disposable pallets with a maximum outside dimensions of 47 ½ inches by 40 inches. Overall height of the pallet and contents shall be no greater than 47 inches. Fork entry of the pallet **shall** be on the long sides of the pallet. No portion of the load **shall** overhang or extend beyond any pallet edge. Shrink wrapping to secure intermediate containers is encouraged.

5.4 Packaging Marking

Unit, intermediate packages, and palletized shipments **shall** be marked IAW MIL-STD-129. Each intermediate package and each shipping container **shall** be durably marked with the following information:

National Stock Number (NSN):

Cage Code or Manufacturer's Part Number:

Item Description:

Quantity and Unit of Issue:
 Contract/Purchase Order Number:
 Level of Protection and Date Packed:
 Manufacturer's Name and Trade Mark:

6. ADDITIONAL INFORMATION

6.1 Intended Use

6.1.1 Green Threshold LED Light Sources

The green threshold LED light sources will be used in the threshold light array in the MALSR system IAW FAA-E-2325. The threshold light array consists of a row of between 8 and 33 light sources evenly spaced at 10-foot intervals, extending 10 feet beyond each side of the runway. The entire threshold light array will form a straight line of steady burning green lights perpendicular to the centerline of the runway. The number of green threshold LED light sources is determined by the width of the runway at the installation site (for a 150-foot runway, 18 lights are needed).

6.1.2 White Steady Burning LED Light Sources

The white steady burning LED light sources will be used in the steady burning light array in the MALSR system IAW FAA-E-2325. The steady burning light array consists of seven (7) rows containing nine (9) light bars. Each steady burning light bar consists of a row of five (5) white lights, for a total of 45 lights in the array. The steady burning light sources are spaced 2.5 feet apart on each light bar for a total width of 10 feet. The first steady burning light bar, located closest to the runway threshold, is 200 feet from the threshold light array on the extended runway centerline. The orientation of the first steady burning light bar in relation to the threshold array is depicted in D-6292-8. Each successive steady burning light bar row is 200 feet from the previous row. The fifth row of steady burning light bars, located 1,000 feet from the runway threshold, consists of three (3) light bars installed side-by-side 28 feet apart (center to center). The 1,000 foot bars will operate identically to the rest of the steady burning light bars.

6.2 Design Considerations

6.2.1 LED Driver Circuit

To produce the light intensity steps, LED light source may incorporate a pulse width modulation circuit (PWM). If a PWM driver circuit is used, the pulse repetition rate **shall** be no less than 120Hz.

6.2.2 Recycled, Recovered, or Environmentally Preferable Materials

Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

6.2.3 Laser Diode Application for the Infrared Source

The infrared radiation requirement may be met by the use of laser diodes. In order for Enhanced Flight Vision System equipped aircraft to best make use of the radiation a minimum of three wavelengths in the 1,300 nm to 1,800 nm band should be incorporated into the emission. Eye safety shall be taken into consideration if laser diodes are used as the infrared radiation source.

6.3 Implementation Considerations

6.3.1 Power Transformer

The 10-15 KVA power transformer in the MALSR System may need to be replaced to accommodate the lower power consumption of the LED light sources.

6.4 Government Furnished Equipment

PAR-56 Lampholders;
See TABLE III. PAR-56 Lampholders
PAR-38 Lampholders;
See TABLE V. PAR-38 Lampholders
Lampholder Aiming Devices;
FA-11507
FA-10290/6
FA-10267/6
FA-10267/7
FA-10097/6
FA-9877 UNIT-4
FA-9629/4
FA-9426/4
FA-8767/4
FA-8091/3 (Multi-Electric #4611)
Frangible Coupling IAW C-6046

6.5 Definitions

Green Threshold LED Light Source – The non-repairable LRU that interfaces (mechanically and electrically) with the PAR-56 lampholder and emits aviation green colored light. The LED Light source includes the individual LEDs, Circuitry, Heaters, Light Window, Lens, Electrical Plug, Fastening Mechanism, Enclosure, etc.

LED Light Source – A general term that represents both the Threshold LED Light Source and the Steady Burning LED Light Source.

Lowest Replaceable Unit (LRU) – An essential support item which is removed and replaced at the field level to restore the end item to an operational ready condition.

White Steady Burning LED Light Source – The non-repairable LRU that interfaces (mechanically and electrically) with the PAR-38 lampholder and emits aviation white colored light. The LED Light source includes the individual LEDs, Circuitry, Heaters, Light Window, Lens, Electrical Plug, Fastening Mechanism, Enclosure, etc.

APPENDIX A. LED Light Source Requirements Verification Traceability Matrix

Key: I – Inspect, D – Demonstrate, T – Test, A – Analysis

DQT – Design Qualification Test, PAT – Production Acceptance Test

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
1	3.1.1	The green threshold LED light source shall be a direct replacement for the MALSR above-ground incandescent PAR-56 lamp with a green filter.	D	D	4.4.11.1, 4.4.11.2
2	3.1.1	The green threshold LED light source shall interface, mechanically and electrically, with the current PAR-56 lampholder in accordance with (IAW) FAA-E-982 and with the lampholders identified in TABLE III.	D	D	4.4.11.1, 4.4.11.2
3	3.1.1	No modification to the PAR-56 lampholder shall be required to install and operate the green threshold LED light source.	D	D	4.4.11.1, 4.4.11.2
4	3.1.1	The green threshold LED light source shall properly operate using the existing electrical and control signals provided by the MALSR.	D	D	4.4.11.1, 4.4.11.2
5	3.1.2	The green threshold LED light source shall meet all the following requirements over the environmental operating conditions specified in 3.6.	T		4.4.2 thru 4.4.2.10
6	3.1.2.1	The green threshold LED light source beam shall exhibit an elliptical shape defined by the standard ellipse equation: $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$ <p>where X is the horizontal axis coordinate and Y is the vertical axis coordinate.</p>	T		4.4.3, 4.4.3.1.1
7	3.1.2.1	The outer bounds of the light beam shall be no closer than $\pm 6^\circ$ from the light unit centerline along the horizontal axis (a = 6) and shall be no closer than $\pm 4^\circ$ from the light unit centerline along the vertical axis (b = 4).	T		4.4.3, 4.4.3.1.1

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
8	3.1.2.2	The aviation green colored output of the green threshold LED light source shall produce three intensity steps that are determined by the input voltage.	D	D	4.4.11.1, 4.4.11.2
9	3.1.2.2	Within the light beam pattern described in 3.1.2.1, the average intensity shall be within the required levels for each intensity step as stated in TABLE I	T		4.4.3, 4.4.3.1.3
10	3.1.2.3	Within the light beam pattern described in 3.1.2.1, no measured intensity shall be less than the minimum allowable intensity listed in TABLE II for each intensity step.	T		4.4.3, 4.4.3.1.4
11	3.1.2.3	Within the light beam pattern described in 3.1.2.1, the maximum measured intensity shall be no greater than the maximum allowable intensity listed in TABLE II for each intensity step.	T		4.4.3, 4.4.3.1.4
12	3.1.2.3	The maximum measured light intensity shall reside within $\pm 3^\circ$ circle of the light unit centerline (see FIGURE 1).	T		4.4.3, 4.4.3.1.4
13	3.1.2.4	The intensity of the green threshold LED light source output at $70^\circ\text{C} \pm 2^\circ\text{C}$ shall be no less than 80% of the intensity at $25^\circ\text{C} \pm 2^\circ\text{C}$.	T		4.4.3.1.4
14	3.1.2.5	The color of the light emitted from the threshold LED light source shall be Aviation Green as specified in SAE-AS25050.	T	T	4.4.3, 4.4.3.1.5
15	3.1.2.5	Within the Aviation Green color specification, the light emitted from the threshold LED light source shall have a dominate wavelength less or equal to 530 nanometers (nm) and greater or equal to 500 nm			
16	3.1.2.5	If multiple LEDs are used within a single threshold light source, each LED shall meet both the Aviation Green as specified in SAE-AS25050 and be within the dominate wavelength band.	I	I	4.4.1
17	3.1.2.5	Deleted			

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
18	3.1.2.6	The green threshold LED light source shall have an integrated infrared power output greater than 21.0 watts/steradian between 1,300 nm and 1,800 nm or greater than 8.3 W/sr between 3,400 nm and 4,200 nm.	T		4.4.3
19	3.1.2.6	The green threshold LED light source infrared beam shall be defined by the outer beam pattern in paragraph 3.1.2.1.	T		4.4.3
20	3.1.3.1	The green threshold LED light source shall occupy the available volume allocated to the standard PAR-56 lamp and green filter used in the PAR-56 lampholder.	I		4.4.1
21	3.1.3.2	The green threshold LED light source shall weigh no greater than three (3) pounds (lbs).	T		4.4.5
22	3.1.3.3	The location of the center of gravity for the green threshold LED light source shall not adversely affect the ability of the PAR-56 Light Assembly to remain locked at a aiming angle while exposed to the combined wind and ice conditions specified in 3.6.1.6.	D		
23	3.1.3.4	The green threshold LED light source shall operate over the entire vertical alignment range from 0° horizontal to 10° horizontal.	D		4.4.6
24	3.1.3.4	The threshold LED light source shall not interfere with the mounting and proper function of the PAR-56 lampholder Aiming Device.	D		4.4.6
25	3.1.3.4	The green threshold LED light source shall not interfere with the light assembly vertical alignment process.	D		4.4.6
26	3.1.4	The green threshold LED light source shall interface and operate properly in the existing PAR-56 lampholders (see TABLE III) currently installed in the National Aerospace System.	D		4.4.8
27	3.1.4.1	The green threshold LED light source shall be mounted into the PAR-56 lampholder using the exiting lamp clip mechanism IAW FAA-E-982 paragraph 3.3.1.2.	I	I	4.4.1

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
28	3.1.4.2	The green threshold LED light source shall have a Mogul End, Straight Prong connector IAW FAA-E-2408b paragraph 3.6.4.	I/D	I/D	4.4.1, 4.4.11.1, 4.4.11.2
29	3.1.5	The average wattage rating of the green threshold LED light source shall be no greater than 45W, with a goal of 30W.	T	T	4.4.4.9
30	3.2.1	The white steady burning LED light source shall be a direct replacement for the MALSR above-ground incandescent PAR-38 lamp.	D	D	4.4.11.1, 4.4.11.2
31	3.2.1	The white steady burning LED light source shall interface, mechanically and electrically, with the current PAR-38 lampholders specified in TABLE V	D	D	4.4.11.1, 4.4.11.2
32	3.2.1	No modification to the PAR-38 lampholder shall be required to install and operate the white steady burning LED light source.	D	D	4.4.11.1, 4.4.11.2
33	3.2.1	The white steady burning LED light source shall properly operate using the existing electrical and control signals provided by the MALSR.	D	D	4.4.11.1, 4.4.11.2
34	3.2.2	The white steady burning LED light sources shall meet all the following requirements over the environmental operating conditions specified in 3.6.1.	D	D	4.4.11.1, 4.4.11.2
35	3.2.2.1	The white steady burning LED light beam pattern shall be circular in shape (shown in FIGURE 2).	T		4.4.3, 4.4.3.2.1
36	3.2.2.1	The outer bounds of the main-beam pattern shall be no closer than $\pm 8^\circ$. The full width half maximum shall be $\pm 8^\circ$.	T		4.4.3, 4.4.3.2.1
37	3.2.2.2	The aviation white output of the steady burning LED light source shall produce three intensity steps that are determined by the input voltage.	D	D	4.4.11.1, 4.4.11.2
38	3.2.2.2	Within the main beam pattern described in 3.2.2.1, the average intensity shall be within the required levels as stated in TABLE IV.	T		4.4.3, 4.4.3.2.3
39	3.2.2.3	Within the main-beam (see FIGURE 2), no measured intensity point shall be greater than 12,000 Candela.	T		4.4.3, 4.4.3.2.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
40	3.2.2.3	Deleted			
41	3.2.2.4	The intensity of the white steady burning LED light source output at 70°C ±2°C shall be no less than 80% of the intensity at 25°C ±2°C.	T		4.4.3.2.4
42	3.2.2.5	The color of the light emitted from the steady burning LED light source shall be Aviation White as specified in SAE-AS25050.	T	I	4.4.3, 4.4.3.2.5
43	3.2.2.5	Within the Aviation White color specification, the light emitted from the steady burning LED light source shall have a color temperature less or equal to 4500K and greater or equal to 2750K			
44	3.2.2.5	If multiple LEDs are used within a steady burning light source, each element shall meet both the Aviation White as specified in SAE-AS25050 and be within the color temperature band.	I	I	4.4.1
45	3.2.2.5	Deleted			
46	3.2.2.6	The white steady burning LED light source shall have an integrated infrared power output greater than 8.2 watts/steradian between 1,300 nm and 1,800 nm or greater than 3.3 W/sr between 3,400 nm and 4,200 nm.	T		4.4.3
47	3.2.2.6	The white steady burning LED light source infrared beam shall be defined by a ±8° beam pattern along the optical centerline of the LED light source.	T		4.4.3
48	3.2.3.1	The white steady burning LED light source shall occupy the available volume allocated to the standard PAR-38 lamp used in the PAR-38 lampholder.	I		4.4.1
49	3.2.3.2	The white steady burning LED light source shall weigh no greater than two and a half (2.5) lbs. with a goal of one and a half (1.5) lbs.	T		4.4.5
50	3.2.3.3	The location of the center of gravity for the white steady burning LED light source shall not adversely affect the ability of the PAR-38 Light Assembly to remain locked at an aiming angle while exposed to the combined wind and ice conditions specified in 3.6.1.6.	D		

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
51	3.2.3.4	The white steady burning LED light source shall operate over the entire vertical alignment range from 0° horizontal to 10° horizontal.	D		4.4.6
52	3.2.3.4	The white steady burning LED light source shall not interfere with the mounting and proper function of the PAR-38 lampholder Aiming Device.	D		4.4.6
53	3.2.3.4	The white steady burning LED light source shall not interfere with the light assembly vertical alignment process.	D		4.4.6
54	3.2.4	The white steady burning LED light source shall interface and operate properly in the existing PAR-38 Lampholders (see TABLE V) currently installed in the National Airspace System.			
55	3.2.4.1	The white steady burning LED Light Sources shall have a Medium Screw, Skirted Base (E26) IAW ANSI/IEC C81.61.	I/D	I/D	4.4.1, 4.4.11.1, 4.4.11.2
56	3.2.5	The average wattage rating of the white steady burning LED light source shall be no greater than 45W, with a goal of 30W.	T	T	4.4.4.9
57	3.3	Unless otherwise specified, all circuitry, wiring, and enclosures shall meet National Fire Prevention Association (NFPA) 70 requirements.	I	I	4.4.1
58	3.3.1.1	The LED light source shall produce three light intensities at three discrete input line voltages as described in TABLE VI.	T/D	D	4.4.4.3, 4.4.11.1, 4.4.11.2
59	3.3.1.2	The LED light source shall accept input power at a frequency of 60 Hertz (Hz). The LED light source shall not be damaged or experience performance degradation with steady state or momentary deviation in input frequency as specified in paragraph 3.1.1.7c of FAA-G-2100h.	T		4.4.4.1
60	3.3.1.3	The LED light source shall not experience performance degradation with input voltage harmonic distortions as specified in Paragraph 3.1.1.7d of FAA-G-2100h.	T		4.4.4.1
61	3.3.1.4	The LED light source shall operate properly and not be damaged by voltage variations of $\pm 2.5\%$ VAC at each intensity level.	T		4.4.4.3

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
62	3.3.1.5	The LED light source shall not produce current harmonic distortions as specified in Paragraph 3.1.1.5 of FAA-G-2100h			
63	3.3.1.6	The LED light source power factor shall be IAW 3.1.1.3.1 of FAA-G-2100h			
64	3.3.2.1	Power interfaces for the LED light source shall be protected and not be damaged from any power line surges as specified in FAA-STD-019e, Paragraph 4.2.2.	T		4.4.4.7
65	3.3.2.2	The power interfaces for the LED light source shall provide conducted line transient protection as specified in FAA-STD-019e, Paragraph 4.2.2.1.	T		4.4.4.8
66	3.3.2.2	The LED light source shall be operational when exposed to a combination waveform consisting of a 1.2/50μs voltage spike at 10kV and an 8/20μs current spike at 10kA.	T		4.4.4.8
67	3.3.2.3	The LED light source performance shall not be damaged by facility power outage conditions.	D	D	4.4.4.2,4.4.4.13
68	3.3.2.3	Any solid-state devices within the LED light source shall remain active for 100 ms following a power interruption to avoid an inadvertent light source outage.	T	D	4.4.4.2
69	3.3.2.3	The LED light source shall automatically reset, if necessary, on power restoration, or in the event of a power interruption.	D	D	4.4.4.2
70	3.3.3	The LED light source driver circuit shall respond to an intensity step change in less than one (1) seconds after receiving the change of input voltage.	T		4.4.11.1
71	3.3.4	Electrical grounding for the LED light source shall be IAW with the National Electric Code as outlined in FAA-STD-019e Paragraphs 4.2.10 and 4.3.4.	D	D	4.4.4.13

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
72	3.3.5	Electrical bonding for the LED light source shall be IAW FAA-STD-019e Paragraph 4.1.1.	D	D	4.4.4.13
73	3.3.6	Electrical shielding for the LED light source shall be IAW FAA-STD-019e Paragraph 4.1.2.	D	D	4.4.4.11
74	3.3.7	Lightning Protection for the LED light source shall be IAW FAA-STD-019e Paragraph 4.2.3.	A		N/A
75	3.4.1	The LED light source shall meet the Conducted Emission Interference requirements of CE102 specified in MIL-STD-461F with a frequency range of 10 kHz to 10 MHz.	T		4.4.4.11
76	3.4.2	The LED light source shall meet the Radiated Emission Interference requirements of RE102, Figure RE102-4 for ground application, specified in MIL-STD-461F with the exception that the frequency range tested shall be 2 MHz to 10 GHz.	T		4.4.4.11
77	3.4.3	The LED light source shall meet the Conducted Susceptibility requirements of CS114 specified in MIL-STD-461F. The frequency range shall be 10 kHz to 200 MHz, and Curve #2 of Figure CS114-1 of MIL-STD-461F shall be used for the limit IAW Table III for Navy ground equipment.	T		4.4.4.11
78	3.4.4	The LED light source shall meet the Radiated Susceptibility requirements of RS103 defined in MIL-STD-461F. The frequency range shall be 2 MHz to 18 GHz. The electric field intensity shall be IAW the limits for Navy ground equipment to Table VII RS103 limits for Navy ground equipment of MIL-STD-461F.	T		4.4.4.11
79	3.5	The LED light source shall provide ESD protection to reduce the frequency of ESD events and to minimize the effects as outlined in FAA-STD-019e paragraph 4.3.7. All electronic circuitry that contain miniaturized or solid-state components shall be considered ESD susceptible.	T		4.4.4.12

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
80	3.6.1	The LED light source shall operate continuously and intermittently under the environmental conditions specified.	T		4.4.2 thru 4.4.2.10
81	3.6.1	The LED light source shall be capable of performing satisfactorily under the conditions specified in Paragraph 3.2.1.1.2 of FAA-G-2100h for common outdoor operating environmental conditions except where the requirements in the following subsections differ.	T		4.4.2 thru 4.4.2.10
82	3.6.1.1	The LED light source shall exhibit no adverse effects during operation at temperature ranges at all specified climate categories in Table C-1 of MIL-STD-810F.	T		4.4.2, 4.4.2.1
83	3.6.1.2	The LED light source shall exhibit no adverse effects during operation at relative humidity levels over all climate categories defined in Table C-1 of MIL-STD-810F.	T		4.4.2, 4.4.2.2
84	3.6.1.3	The LED light source shall exhibit no adverse effects during operations at an altitude range from -300 feet to 10,000 feet as specified in FAA-G-2100h.	T		4.4.2, 4.4.2.3
85	3.6.1.4	The LED light source shall exhibit no adverse effects during exposure to wind blown sand and dust particles of 5,700 feet/minute (ft/min) (29 meters/second (m/s)) and 1,750 ft/min (8.9 m/s) respectively.	T		4.4.2, 4.4.2.4
86	3.6.1.5	The LED light source shall operate under exposure to salt-laden atmosphere with relative humidity as stated in 3.6.1.2.	T		4.4.2, 4.4.2.5
87	3.6.1.6	The LED light source shall operate under exposure to wind blown rain at rain rates up to 4 inches/hour and wind velocities up to 40 miles per hour (mph).	T		4.4.2, 4.4.2.6
88	3.6.1.7	The LED light source shall withstand exposure of external surfaces (including the light window) to a sudden application of cold (0° C to 5° C) water when the lights reach stable temperatures in the high intensity mode.	T		4.4.2, 4.4.2.7

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
89	3.6.1.8	The LED light source shall operate under exposure to sunshine as specified for all climate categories as defined in Table C-1 of MIL-STD-810F using the spectral energy distribution in Table 505.4-I.	T		4.4.2, 4.4.2.8
90	3.6.1.9	The LED light source installed in the lampholder shall be capable of withstanding vibrations as defined by figure 514.5C-14 in MIL-STD-810F using the parameters presented in TABLE VII.	T		4.4.2, 4.4.2.9
91	3.6.1.10	The energized LED light source shall prevent the accumulation of ice on the face of the light source when exposed to an ambient air temperature of -10°C ± 2°C and water droplet temperature of 0°C to 3°C.	T		4.4.2, 4.4.2.10
92	3.6.2	The LED light source shall not be damaged when stored or transported under conditions delineated in the non-operating conditions specified in Paragraph 3.2.1.2 of FAA-G-2100h.	A		N/A
93	3.7.1	The LED light source Mean Time Between Failures (MTBF) shall be greater than 50,000 hours. The LED light source is considered “failed” once the visible or infrared output has degraded beyond 80 percent of its original light output or when 25 percent of the emitters in the light source have failed to emit light.	D	D	4.1.1
94	3.7.2	The LED light source shall be a “throw-away” Line Replaceable Unit (LRU).	I		4.4.1
95	3.7.2	No preventive maintenance on the LED light source shall be required.	D		4.1.1
96	3.7.2	The LED light source shall be replaced and be operational in less than 5 minutes.	D		4.1.2
97	3.8	The LED light source shall interface and operate properly, at each intensity step, in existing MALSRs (See Table VIII) installed in the National Airspace System			
98	3.9.1	Materials that are nutrients for fungi shall not be used.	I		4.4.1

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
99	3.9.2	Materials that degrade or deteriorate when subjected to ultra-violet radiation shall be protected with the appropriate coating.	T		4.4.2, 4.4.2.8
100	3.9.3	Metals used in the housing of the LED light source shall be compatible with the material used in their respective lampholder.	I		4.4.1
101	3.9.3	Metals shall be corrosion resistant or be suitably treated to resist oxidation and environmental conditions (see 3.6) that may be encountered in storage and normal service.	I		4.4.1
102	3.9.4	Metal surfaces of the LED light source that extend beyond the lampholder shall be painted Aviation Orange IAW FED-STD-595	I		4.4.1
103	3.9.5	The thermal design of the LED light sources shall ensure that the maximum temperature of the heat sink on which the LED array is mounted is 20°C less than the manufacturers' maximum rated junction temperature for the LED during full current (high intensity) operation in a total (ambient plus solar radiation) heat load of 70°C.	T	T	4.4.4.10
104	3.9.5	The thermal design of the LED light sources shall direct heat dissipation through the light window to help prevent ice accumulation.	A		N/A
105	3.9.6	The LED light source design shall prevent internal condensation and accumulation of moisture.	I/D		4.4.1, 4.4.2.1, 4.4.2.2, 4.4.2.7
106	3.9.7	Each LED light source shall be marked in the back with: Ordering Designation, Average Intensity, LED Dominant Wavelength Bin, LED Luminous Intensity (flux) Bin LED Forward Voltage Bin, Day, Month, and Year of Manufacture, and Manufacturer's Name, Logo, Trademark, or Cage Number.	I	I	4.4.1

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	D Q T	P A T	Verification Section
107	3.9.7	The marking shall be permanent and remain legible for the life of the light source. Stick on labels shall be used.	I	I	4.4.1
108	3.9.8	Each LED light source shall be free of blemishes and defects.	I	I	4.4.1
109	3.9.8	Soldering, welding, brazing, cementing, and wiring shall be thorough.	I	I	4.4.1
110	3.9.8	Alignment of parts shall be accurate.	I	I	4.4.1
111	3.9.8	The mogul end prongs shall be straight, without bends, twists, or burrs.	I	I	4.4.1
112	3.9.8	The LED light source shall be free of loose internal items and debris.	I	I	4.4.1
113	3.9.9	Each LED light source shall be thoroughly cleaned.	I	I	4.4.1
114	3.9.9	Loose, spattered or excess solder, metal chips, flux and other foreign material shall be removed during and after final assembly of the LED light source.	I	I	4.4.1

APPENDIX B. LED Light Source Requirements Validation Matrix

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
1	3.1.1	The green threshold LED light source shall be a direct replacement for the MALSR above-ground incandescent PAR-56 lamp with a green filter.	FAA-E-2325, Para. 3.2
2	3.1.1	The green threshold LED light source shall interface, mechanically and electrically, with the current PAR-56 lampholder in accordance with (IAW) FAA-E-982 and with the lampholders identified in TABLE III.	FAA-E-2325, Para. 3.2.2.1
3	3.1.1	No modification to the PAR-56 lampholder shall be required to install and operate the green threshold LED light source.	FAA-E-2325, Para. 3.2.2.1
4	3.1.1	The green threshold LED light source shall properly operate using the existing electrical and control signals provided by the MALSR.	FAA-E-2325, Para. 3.2
5	3.1.2	The green threshold LED light source shall meet all the following requirements over the environmental operating conditions specified in 3.6.	FAA-E-2980, Para. 3.1.1.2
6	3.1.2.1	The green threshold LED light source beam shall exhibit an elliptical shape defined by the standard ellipse equation: $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$ <p>where X is the horizontal axis coordinate and Y is the vertical axis coordinate.</p>	FAA-E-2980, Para. 3.1.1.2.1
7	3.1.2.1	The outer bounds of the light beam shall be no closer than $\pm 6^\circ$ from the light unit centerline along the horizontal axis (a = 6) and shall be no closer than $\pm 4^\circ$ from the light unit centerline along the vertical axis (b = 4).	FAA-E-2980, Para. 3.1.1.2.1
8	3.1.2.2	The aviation green colored output of the green threshold LED light source shall produce three intensity steps that are determined by the input voltage.	FAA-E-2980, Para. 3.1.1.2.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
9	3.1.2.2	Within the light beam pattern described in 3.1.2.1, the average intensity shall be within the required levels for each intensity step as stated in TABLE I	FAA-E-2980, Para. 3.1.1.2.2
10	3.1.2.3	Within the light beam pattern described in 3.1.2.1, no measured intensity shall be less than the minimum allowable intensity listed in TABLE II for each intensity step.	FAA-E-2980, Para. 3.1.1.2.3
11	3.1.2.3	Within the light beam pattern described in 3.1.2.1, the maximum measured intensity shall be no greater than the maximum allowable intensity listed in TABLE II for each intensity step.	FAA-E-2980, Para. 3.1.1.2.3
12	3.1.2.3	The maximum measured light intensity shall reside within $\pm 3^\circ$ circle of the light unit centerline (see FIGURE 1).	FAA-E-2980, Para. 3.1.1.2.3
13	3.1.2.4	The intensity of the green threshold LED light source output at $70^\circ\text{C} \pm 2^\circ\text{C}$ ambient shall be no less than 80% of the intensity at $25^\circ\text{C} \pm 2^\circ\text{C}$ ambient.	FAA-E-2980, Para. 3.1.1.2.2
14	3.1.2.5	The color of the light emitted from the threshold LED light source shall be Aviation Green as specified in SAE-AS25050.	FAA-E-2980, Para. 3.1.1.2.4
15	3.1.2.5	Within the Aviation Green color specification, the light emitted from the threshold LED light source shall have a dominate wavelength less or equal to 530 nanometers (nm) and greater or equal to 500 nm	
16	3.1.2.5	If multiple LEDs are used within a single threshold light source, each LED shall meet both the Aviation Green as specified in SAE-AS25050 and be within the dominate wavelength band.	FAA-E-2980, Para. 3.1.1.2.4
17	3.1.2.5	Deleted	FAA-E-2980, Para. 3.1.1.2.4
18	3.1.2.6	The green threshold LED light source shall have an integrated infrared power output greater than 21.0 watts/steradian between 1,300 nm and 1,800 nm or greater than 8.3 W/sr between 3,400 nm and 4,200 nm.	

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
19	3.1.2.6	The green threshold LED light source infrared beam shall be defined by the outer beam pattern in paragraph 3.1.2.1.	
20	3.1.3.1	The green threshold LED light source shall occupy the available volume allocated to the standard PAR-56 lamp and green filter used in the PAR-56 lampholder.	FAA-E-982, Para. 3.3
21	3.1.3.2	The green threshold LED light source shall weigh no greater than three (3) pounds (lbs).	ORPHAN Total Wt Req for Lamp and Holder is 6.5 lbs (FAA-E-2980) NBP/DME PAR-56 weighs 3 lbs. Leaves 3.5lbs for Lamp & Filter. LIC's 1 st Prototype weighs 3.5lbs
22	3.1.3.3	The location of the center of gravity for the green threshold LED light source shall not adversely affect the ability of the PAR-56 Light Assembly to remain locked at a aiming angle while exposed to the combined wind and ice conditions specified in 3.6.1.6.	FAA-E-2325, Para. 3.2.2.1
23	3.1.3.4	The green threshold LED light source shall operate over the entire vertical alignment range from 0° horizontal to 10° horizontal.	FAA-E-2325, Para. 3.2.9
24	3.1.3.4	The threshold LED light source shall not interfere with the mounting and proper function of the PAR-56 lampholder Aiming Device.	FAA-E-2325, Para. 3.2.9
25	3.1.3.4	The green threshold LED light source shall not interfere with the light assembly vertical alignment process.	FAA-E-2325, Para. 3.2.9
26	3.1.4	The green threshold LED light source shall interface and operate properly in the existing PAR-56 lampholders (see TABLE III) currently installed in the National Aerospace System.	FAA-G-2100, Para. 3.3.4

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
27	3.1.4.1	The green threshold LED light source shall be mounted into the PAR-56 lampholder using the exiting lamp clip mechanism IAW FAA-E-982 paragraph 3.3.1.2.	FAA-E-982, Para. 3.3.1.2.
28	3.1.4.2	The green threshold LED light source shall have a Mogul End, Straight Prong connector IAW FAA-E-2408b paragraph 3.6.4.	FAA-E-2408, Para. 3.6.4
29	3.1.5	The average wattage rating of the green threshold LED light source shall be no greater than 45W, with a goal of 30W.	ORPHAN Derived from Preliminary Power Budget Data
30	3.2.1	The white steady burning LED light source shall be a direct replacement for the MALSR above-ground incandescent PAR-38 lamp.	FAA-E-2325, Para. 3.2
31	3.2.1	The white steady burning LED light source shall interface, mechanically and electrically, with the current PAR-38 lampholders specified in TABLE V	
32	3.2.1	No modification to the PAR-38 lampholder shall be required to install and operate the white steady burning LED light source.	FAA-E-2325, Para. 3.2.2.2
33	3.2.1	The white steady burning LED light source shall properly operate using the existing electrical and control signals provided by the MALSR.	FAA-E-2325, Para. 3.2
34	3.2.2	The white steady burning LED light sources shall meet all the following requirements over the environmental operating conditions specified in 3.6.1.	FAA-E-2325, Para. 3.2
35	3.2.2.1	The white steady burning LED light beam pattern shall be circular in shape (shown in FIGURE 2).	FAA-E-2980, Para. 3.1.2.2.1
36	3.2.2.1	The outer bounds of the main-beam pattern shall be no closer than $\pm 8^\circ$. The full width half maximum shall be $\pm 8^\circ$.	FAA-E-2980, Para. 3.1.2.2.1
37	3.2.2.2	The aviation white output of the steady burning LED light source shall produce three intensity steps that are determined by the input voltage.	FAA-E-2980, Para. 3.1.2.2.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
38	3.2.2.2	Within the main beam pattern described in 3.2.2.1, the average intensity shall be within the required levels as stated in TABLE IV.	FAA-E-2980, Para. 3.1.2.2.2
39	3.2.2.3	Within the main-beam (see FIGURE 2), no measured intensity point shall be greater than 12,000 Candela.	FAA-E-2980, Para. 3.1.2.2.3
40	3.2.2.3	Deleted	
41	3.2.2.4	The intensity of the white steady burning LED light source output at 70°C $\pm 2^\circ\text{C}$ ambient shall be no less than 80% of the intensity at 25°C $\pm 2^\circ\text{C}$ ambient.	FAA-E-2980, Para. 3.1.2.2.2
42	3.2.2.5	The color of the light emitted from the steady burning LED light source shall be Aviation White as specified in SAE-AS25050.	FAA-E-2980, Para. 3.1.2.2.4
43	3.2.2.5	Within the Aviation White color specification, the light emitted from the steady burning LED light source shall have a color temperature less or equal to 4500K and greater or equal to 2750K	
44	3.2.2.5	If multiple LEDs are used within a steady burning light source, each element shall meet both the Aviation White as specified in SAE-AS25050 and be within the color temperature band.	FAA-E-2980, Para. 3.1.2.2.4
45	3.2.2.5	Deleted	
46	3.2.2.6	The white steady burning LED light source shall have an integrated infrared power output greater than 8.2 watts/steradian between 1,300 nm and 1,800 nm or greater than 3.3 W/sr between 3,400 nm and 4,200 nm.	
47	3.2.2.6	The white steady burning LED light source infrared beam shall be defined by a $\pm 8^\circ$ beam pattern along the optical centerline of the LED light source.	
48	3.2.3.1	The white steady burning LED light source shall occupy the available volume allocated to the standard PAR-38 lamp used in the PAR-38 lampholder.	FAA-E-2325, Para. 3.2.2.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
49	3.2.3.2	The white steady burning LED light source shall weigh no greater than two and a half (2.5) lbs. with a goal of one and a half (1.5) lbs.	ORPHAN Incandescent Lamp weighs 1.0lbs, LICs LED PAR-38 weighs 2.5 lbs
50	3.2.3.3	The location of the center of gravity for the white steady burning LED light source shall not adversely affect the ability of the PAR-38 Light Assembly to remain locked at a aiming angle while exposed to the combined wind and ice conditions specified in 3.6.1.6.	FAA-E-2325, Para. 3.2.2.2
51	3.2.3.4	The white steady burning LED light source shall operate over the entire vertical alignment range from 0° horizontal to 10° horizontal.	FAA-E-2325, Para. 3.2.2.2
52	3.2.3.4	The white steady burning LED light source shall not interfere with the mounting and proper function of the PAR-38 lampholder Aiming Device.	FAA-E-2325, Para. 3.2.9
53	3.2.3.4	The white steady burning LED light source shall not interfere with the light assembly vertical alignment process.	FAA-E-2325, Para. 3.2.9
54	3.2.4	The white steady burning LED light source shall interface and operate properly in the existing PAR-38 Lampholders (see TABLE V) currently installed in the National Airspace System.	
55	3.2.4.1	The white steady burning LED Light Sources shall have a Medium Screw, Skirted Base (E26) IAW ANSI/IEC C81.61.	FAA-E-2325, Para. 3.2.2.3
56	3.2.5	The average wattage rating of the white steady burning LED light source shall be no greater than 45W, with a goal of 30W.	ORPHAN Derived from Preliminary Power Budget Data
57	3.3	Unless otherwise specified, all circuitry, wiring, and enclosures shall meet National Fire Prevention Association (NFPA) 70 requirements.	FAA-G-2100, Para 3.1.b

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
58	3.3.1.1	The LED light source shall produce three light intensities at three discrete input line voltages as described in TABLE VI.	FAA-E-2325, Para. 3.2.4
59	3.3.1.2	The LED light source shall accept input power at a frequency of 60 Hertz (Hz). The LED light source shall not be damaged or experience performance degradation with steady state or momentary deviation in input frequency as specified in paragraph 3.1.1.7c of FAA-G-2100h.	FAA-E-2980, Para. 3.1.4.2.3
60	3.3.1.3	The LED light source shall not experience performance degradation with input voltage harmonic distortions as specified in Paragraph 3.1.1.7d of FAA-G-2100h.	FAA-E-2980, Para. 3.1.4.2.6
61	3.3.1.4	The LED light source shall operate properly and not be damaged by voltage variations of $\pm 2.5\%$ VAC at each intensity level.	FAA-E-2325, Para. 3.2.4
62	3.3.1.5	The LED light source shall not produce current harmonic distortions as specified in Paragraph 3.1.1.5 of FAA-G-2100h	
63	3.3.1.6	The LED light source power factor shall be IAW 3.1.1.3.1 of FAA-G-2100h	
64	3.3.2.1	Power interfaces for the LED light source shall be protected and not be damaged from any power line surges as specified in FAA-STD-019e, Paragraph 4.2.2.	FAA-E-2980, Para. 3.1.4.3.2.2
65	3.3.2.2	The power interfaces for the LED light source shall provide conducted line transient protection as specified in FAA-STD-019e, Paragraph 4.2.2.1.	FAA-E-2980, Para. 3.1.4.3.2.2
66	3.3.2.2	The LED light source shall be operational when exposed to a combination waveform consisting of a 1.2/50 μ s voltage spike at 10kV and an 8/20 μ s current spike at 10kA.	FAA-E-2980, Para. 3.1.4.3.2.2
67	3.3.2.3	The LED light source performance shall not be damaged by facility power outage conditions.	FAA-E-2980, Para. 3.1.4.3.2.3

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
68	3.3.2.3	Any solid-state devices within the LED light source shall remain active for 100 ms following a power interruption to avoid an inadvertent light source outage.	FAA-E-2980, Para. 3.3.1.1
69	3.3.2.3	The LED light source shall automatically reset, if necessary, on power restoration, or in the event of a power interruption.	FAA-E-2980, Para. 3.3.1.1
70	3.3.3	The LED light source driver circuit shall respond to an intensity step change in less than one (1) seconds after receiving the change of input voltage.	FAA-E-2980, Para. 3.1.4.1.3
71	3.3.4	Electrical grounding for the LED light source shall be IAW with the National Electric Code as outlined in FAA-STD-019e Paragraphs 4.2.10 and 4.3.4.	FAA-E-2980, Para. 3.3.4
72	3.3.5	Electrical bonding for the LED light source shall be IAW FAA-STD-019e Paragraph 4.1.1.	FAA-E-2980, Para. 3.3.4
73	3.3.6	Electrical shielding for the LED light source shall be IAW FAA-STD-019e Paragraph 4.1.2.	FAA-E-2980, Para. 3.3.4
74	3.3.7	Lightning Protection for the LED light source shall be IAW FAA-STD-019e Paragraph 4.2.3.	FAA-E-2980, Para. 3.3.6
75	3.4.1	The LED light source shall meet the Conducted Emission Interference requirements of CE102 specified in MIL-STD-461F with a frequency range of 10 kHz to 10 MHz.	FAA-E-2980, Para. 3.5.1.1
76	3.4.2	The LED light source shall meet the Radiated Emission Interference requirements of RE102, Figure RE102-4 for ground application specified in MIL-STD-461F with the exception that the frequency range tested shall be 2 MHz to 10 GHz.	FAA-E-2980, Para. 3.5.1.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
77	3.4.3	The LED light source shall meet the Conducted Susceptibility requirements of CS114 specified in MIL-STD-461F. The frequency range shall be 10 kHz to 200 MHz, and Curve #2 of Figure CS114-1 of MIL-STD-461F shall be used for the limit IAW Table III for Navy ground equipment.	FAA-E-2980, Para.3.5.1.3
78	3.4.4	The LED light source shall meet the Radiated Susceptibility requirements of RS103 defined in MIL-STD-461F. The frequency range shall be 2 MHz to 18 GHz. The electric field intensity shall be IAW the limits for AF ground equipment to Table VII RS103 limits for Navy ground equipment of MIL-STD-461F.	FAA-E-2980, Para. 3.5.1.4
79	3.5	The LED light source shall provide ESD protection to reduce the frequency of ESD events and to minimize the effects as outlined in FAA-STD-019e paragraph 4.3.7. All electronic circuitry that contain miniaturized or solid-state components shall be considered ESD susceptible.	FAA-E-2980, Para.3.6
80	3.6.1	The LED light source shall operate continuously and intermittently under the environmental conditions specified.	FAA-E-2980, Para. 3.4.1 FAA-E-2325, Para. 3.5
81	3.6.1	The LED light source shall be capable of performing satisfactorily under the conditions specified in Paragraph 3.2.1.1.2 of FAA-G-2100h for common outdoor operating environmental conditions except where the requirements in the following subsections differ.	FAA-E-2980, Para. 3.4.1 FAA-E-2325, Para. 3.5
82	3.6.1.1	The LED light source shall exhibit no adverse effects during operation at temperature ranges at all specified climate categories in Table C-1 of MIL-STD-810F.	FAA-E-2980, Para. 3.4.1.1
83	3.6.1.2	The LED light source shall exhibit no adverse effects during operation at relative humidity levels over all climate categories defined in Table C-1 of MIL-STD-810F.	FAA-E-2980, Para. 3.4.1.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
84	3.6.1.3	The LED light source shall exhibit no adverse effects during operations at an altitude range from -300 feet to 10,000 feet as specified in FAA-G-2100h.	FAA-E-2980, Para. 3.4.1.3
85	3.6.1.4	The LED light source shall exhibit no adverse effects during exposure to wind blown sand and dust particles of 5,700 feet/minute (ft/min) (29 meters/second (m/s)) and 1,750 ft/min (8.9 m/s) respectively.	FAA-E-2980, Para. 3.4.1.4
86	3.6.1.5	The LED light source shall operate under exposure to salt-laden atmosphere with relative humidity as stated in 3.6.1.2.	FAA-E-2980, Para. 3.4.1.5
87	3.6.1.6	The LED light source shall operate under exposure to wind blown rain at rain rates up to 4 inches/hour and wind velocities up to 40 miles per hour (mph).	FAA-E-2980, Para. 3.4.1.6
88	3.6.1.7	The LED light source shall withstand exposure of external surfaces (including the light window) to a sudden application of cold (0° C to 5° C) water when the lights reach stable temperatures in the high intensity mode.	FAA-E-2980, Para. 3.4.1.7
89	3.6.1.8	The LED light source shall operate under exposure to sunshine as specified for all climate categories as defined in Table C-1 of MIL-STD-810F using the spectral energy distribution in Table 505.4-I.	FAA-E-2980, Para. 3.4.1.8
90	3.6.1.9	The LED light source installed in the lampholder shall be capable of withstanding vibrations as defined by figure 514.5C-14 in MIL-STD-810F using the parameters presented in TABLE VII.	FAA-E-2980, Para. 3.4.1.9
91	3.6.1.11	The energized LED light source shall prevent the accumulation of ice on the face of the light source when exposed to an ambient air temperature of -10°C ± 2°C and water droplet temperature of 0°C to 3°C.	FAA-E-2980, Para. 3.4.1.12

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
92	3.6.2	The LED light source shall not be damaged when stored or transported under conditions delineated in the non-operating conditions specified in Paragraph 3.2.1.2 of FAA-G-2100h.	FAA-E-2980, Para. 3.4.2
93	3.7.1	The LED light source Mean Time Between Failures (MTBF) shall be greater than 50,000 hours. The LED light source is considered “failed” once the visible or infrared output has degraded beyond 80 percent of its original light output or when 25 percent of the emitters in the light source have failed to emit light.	FAA-E-2980, Para. 3.9.2
94	3.7.2	The LED light source shall be a “throw-away” Line Replaceable Unit (LRU).	FAA-E-2980, Para. 3.8 FAA-G-2100, Para. 3.1.2.4.3
95	3.7.2	No preventive maintenance on the LED light source shall be required.	FAA-G-2100, Para. 3.1.2.4.3
96	3.7.2	The LED light source shall be replaced and be operational in less than 5 minutes.	FAA-E-2980, Para. 3.7
97	3.8	The LED light source shall interface and operate properly, at each intensity step, in existing MALSRs (See Table VIII) installed in the National Airspace System	
98	3.9.1	Materials that are nutrients for fungi shall not be used.	FAA-E-2408, Para 3.6.1
99	3.9.2	Materials that degrade or deteriorate when subjected to ultra-violet radiation shall be protected with the appropriate coating.	FAA-E-2980, Para. 3.4.1.8
100	3.9.3	Metals used in the housing of the LED light source shall be compatible with the material used in their respective lampholder.	FAA-G-2100, Para. 3.3.1.1.1
101	3.9.3	Metals shall be corrosion resistant or be suitably treated to resist oxidation and environmental conditions (see 3.6) that may be encountered in storage and normal service.	FAA-G-2100, Para. 3.3.1.1.2

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
102	3.9.4	Metal surfaces of the LED light source that extend beyond the lampholder shall be painted Aviation Orange IAW FED-STD-595.	FAA-E-2980, Para. 3.2.2.1
103	3.9.5	The thermal design of the LED light sources shall ensure that the maximum temperature of the heat sink on which LED array is mounted is 20°C less than the manufacturers' maximum rated junction temperature for the LED during full current (high intensity) operation in a total (ambient plus solar radiation) heat load of 70°C.	FAA-G-2100, Para. 3.1.2.5
104	3.9.5	The thermal design of the LED light sources shall direct heat dissipation through the light window to help prevent ice accumulation.	FAA-G-2100, Para. 3.1.2.5
105	3.9.6	The LED light source design shall prevent internal condensation and accumulation of moisture.	FAA-G-2100, Para. 3.1.2.3.3
106	3.9.7	Each LED light source shall be marked in the back with: Ordering Designation, Average Intensity, LED Dominant Wavelength Bin, LED Luminous Intensity (flux) Bin LED Forward Voltage Bin, Day, Month, and Year of Manufacture, and Manufacturer's Name, Logo, Trademark, or Cage Number.	FAA-G-2100, Para. 3.3.6.5 FAA-E-2408, Para 3.7
107	3.9.7	The marking shall be permanent and remain legible for the life of the light source. Stick on labels shall be unacceptable.	FAA-G-2100, Para. 3.3.6.5 FAA-E-2408, Para 3.7
108	3.9.8	Each LED light source shall be free of blemishes and defects.	FAA-E-2408, Para 3.8
109	3.9.8	Soldering, welding, brazing, cementing, and wiring shall be thorough.	FAA-E-2408, Para 3.8
110	3.9.8	Alignment of parts shall be accurate.	FAA-E-2408, Para 3.8
112	3.9.8	The mogul end prongs shall be straight, without bends, twists, or burrs.	FAA-E-2408, Para 3.8

REQ ###	SECTION	REQUIREMENT STATEMENT Note: If there are any discrepancies between the requirement statement in APPENDIX A and Section 3, the verbiage in Section 3 takes precedence.	PARENT REQUIREMENT(S) (Direct or Derived)
113	3.9.8	The LED light source shall be free of loose internal items and debris.	FAA-E-2408, Para 3.8
114	3.9.9	Each LED light source shall be thoroughly cleaned.	FAA-E-2408, Para 3.8
115	3.9.9	Loose, spattered or excess solder, metal chips, flux and other foreign material shall be removed during and after final assembly of the LED light source.	FAA-E-2408, Para 3.8